

User manual

User manual of the Logistics Impact Model application



Revision history

Version	Date	Changes	Updated by	Reviewed by
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1. Introduction

This document is a complete guide on how to use the Logistics Impact Model (LIMO) application. It is **highly recommended** to read this document carefully! LIMO is a domain specific application and requires some training before users are able to use the program.

1.1. About LIMO

LIMO is an open source supply chain simulation tool which has been developed on behalf of [TNO Sustainable Transport and Logistics](#) by students in software engineering and business informatics of [Fontys Venlo Techniek en Logistiek](#).

The tool has been developed for use by logistics consultants and their customers in order to quickly configure supply chains and easily determine the quantitative impact of change(s) in supply chain configurations. The types of costs that can be quantified with LIMO are logistical throughput time and monetary cost related to amongst others transport, handling, planning, administration and compliance in single origin-destination trade lanes (as opposed to supply networks). LIMO does facilitate the modelling of alternative routings by means of scheduled transport legs (which allow for an alternative routing based on a tolerance threshold) and multimodal transport legs (which assign consignments to routings based on weighed distributions).

The Logistics Impact Model application will only support static information as input for the simulation. It cannot be used as real time tracking tool of supply chains (e.g. use live feed information).

For more information about LIMO, please check the [official website](#).

1.2. Reading guide

This manual describes step by step and in chronological order the action to be taken when starting to work with LIMO. It first provides an overview of system requirements (see section 1). Subsequently, an installation guide is provided (see section 2).

Based on the quick-start guide in section 3 and the master data file in the start-up file, a starting user of LIMO can configure basic chains.

In order to be able to configure more advanced chains, e.g. a chain containing multimodal or scheduled transport legs, section 4 provides more insight in the different concepts used in LIMO. section 5 explains how to create a new master data file, or change or extend an existing master data file. section 6 gives more background on creating supply chains and section 7 on simulation results. section 8 provides a list of hotkeys, key combinations providing shortcuts to specific LIMO commands. Finally, section 9 gives some background regarding the original development assignment from TNO to the Fontys LIMO developers and their individual organizations.



2. System requirements

The system requirements of LIMO can be found below. LIMO might work on other operating systems which run Java but the application is only fully tested on Microsoft Windows 7 and 8.1. There are some known issues for Mac users.

- Microsoft Windows 7 or newer Microsoft Windows operating system with administrator privileges
- Screen resolution of at least 1024x768 pixels
- Java Runtime Environment (JRE) v1.7 or higher installed
- Adobe PDF Reader XI or higher installed (only used for help documentation)
- 150MB free hard disk space

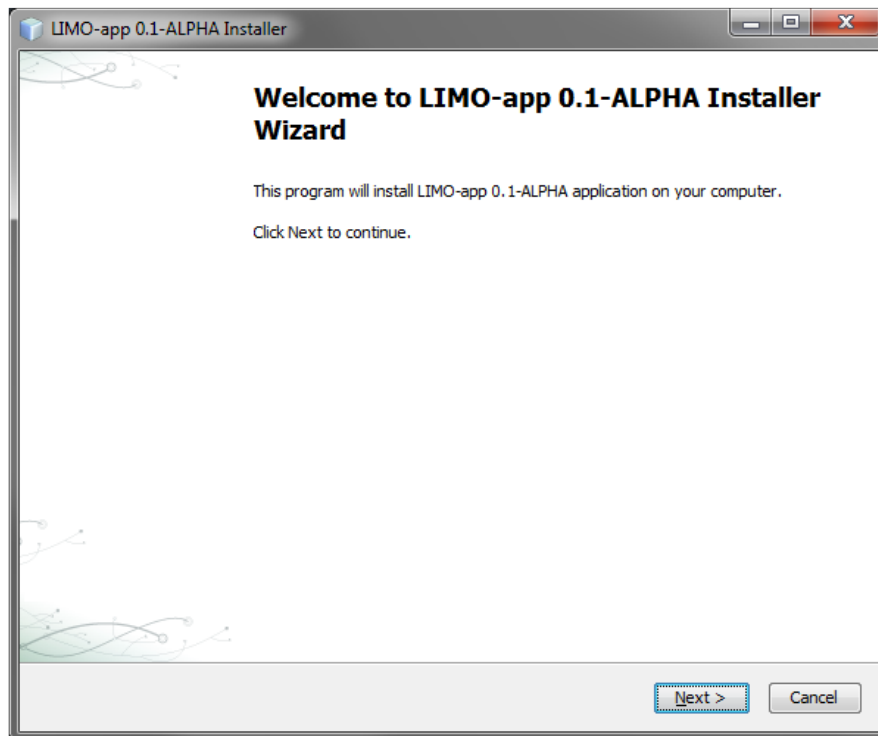
3. Installation guide

This section describes the installation procedure of LIMO. The following overview shows the general installation process. Below this overview, each step is described in detail. For updating LIMO from a previous version, please first read section 3.5.

- Check if your computer meets the system requirements which are described in section 2.
- Download the latest version of LIMO from the [official LIMO website](#).
- (Optional) Download a sample master data set from *Get Started*-guide on the [official LIMO website](#).
- Open the setup.
- Choose the location where LIMO should be installed.
- Start the installation
- Configure that LIMO is always ran with administrator privileges.

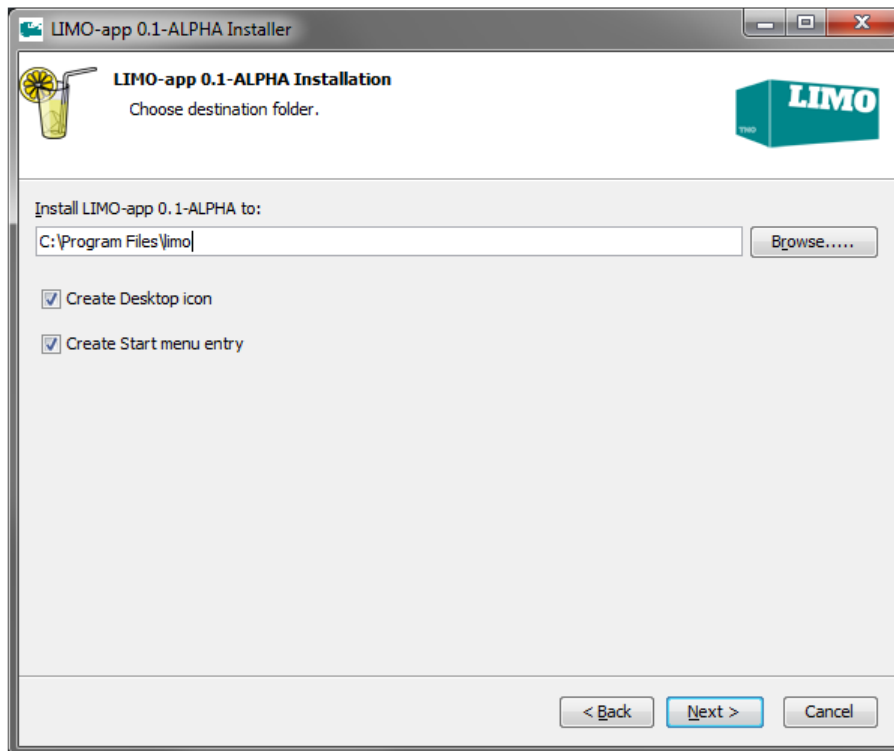
3.1. Open the setup

The following window should appear when opening the setup.



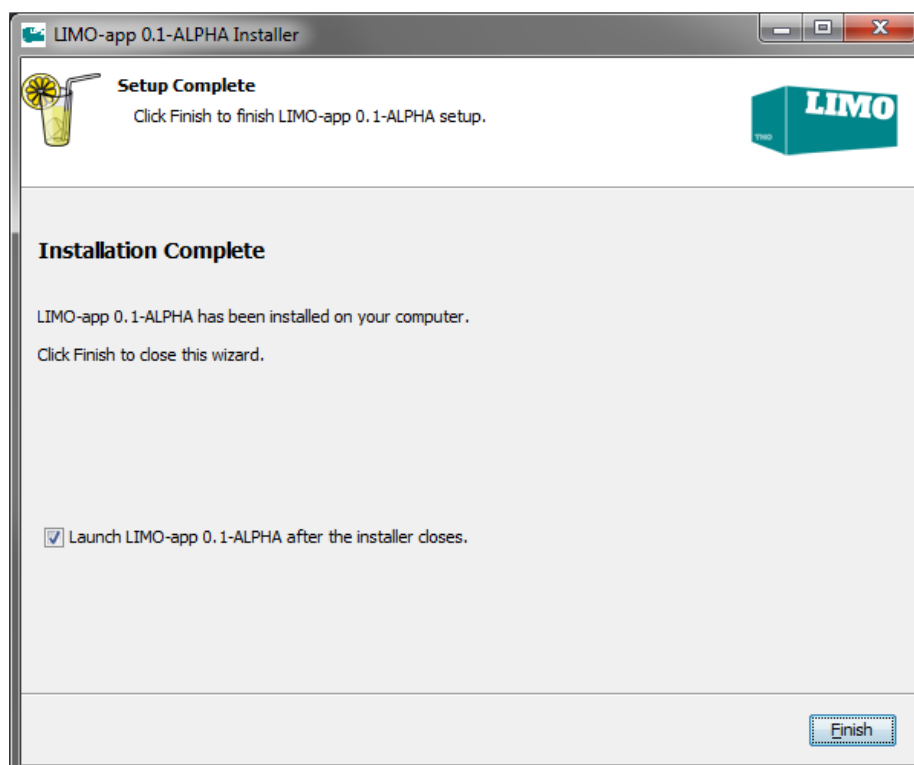
3.2. Select the installation location

Select the installation folder for LIMO by clicking *Browse*. It is recommended to use the default installation location.



3.3. Select the installation location

After the installation is finished, the following windows should appear. It is recommended to deselect the '*Launch LIMO-app after the installer closes*'-option because there is one final step before the installation is finished. This step is described in the next section.



3.4. Configure administrator privileges

As part of the installation, a shortcut was created on the desktop to open LIMO. In order to run LIMO properly, it is important to change this shortcut. This can be done by executing the following steps:

- 1) Navigate to the desktop.
- 2) Right click the LIMO shortcut and click **Properties**.
- 3) In the dialog that appears, navigate to the **Compatibility** tab.
- 4) Select the box **Run this program as administrator**.
- 5) Confirm the change to the LIMO shortcut by clicking OK.



3.5. Updating LIMO from a previous version

To update the LIMO application from a previous version, the following steps are required:

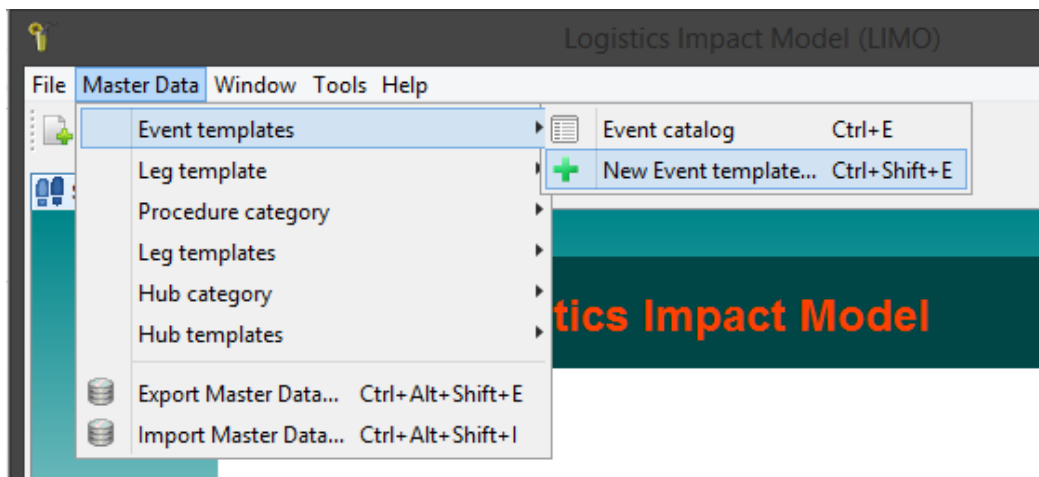
- 1) Export all master data. This is explained in section 6.6.
- 2) Remove the LIMO-folder (by default this is C:\Program Files\limo).
- 3) Install the latest version. This is explained in section 3.
- 4) Import the back-upped master data. This is explained in section 6.7.

4. Starting with LIMO

This chapter explains how to start configuring supply chains in LIMO and how to simulate them. After installing LIMO, master data is required to configure supply chains. It is possible to import master data from an existing file or create the master data yourself. How to create master data yourself is explained in section 3.1. A guide on how to import an existing master data file can be found in section 6.7.

4.1. Creating master data

If you want to add an event to a hub or a leg when making your first supply chain, an event has to be created in the event templates catalog. This can be done by clicking on *Master Data*, then *Event templates* ► *New Event template* or press CTRL+SHIFT+E. Follow the instructions of the event wizard. For more information creating an event, see section 5.5: Events.



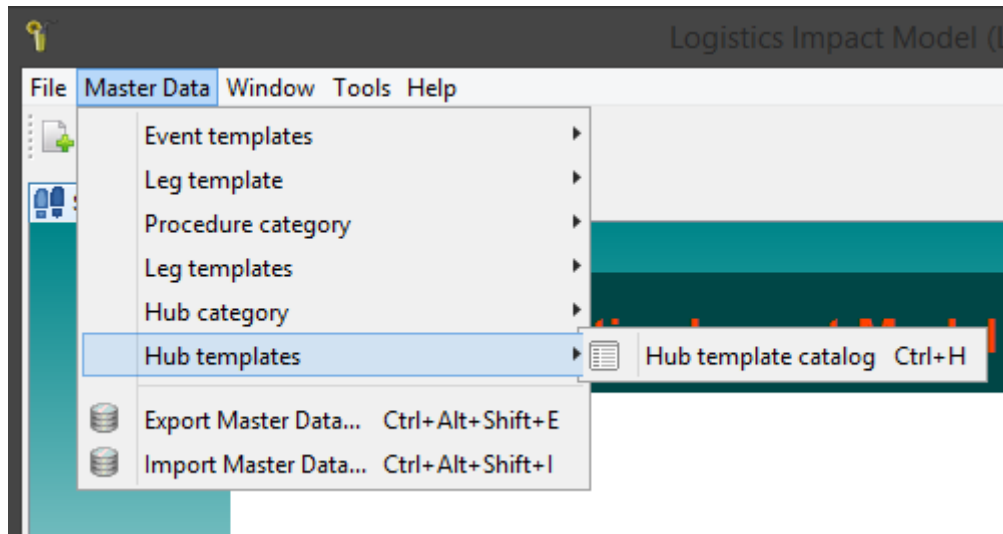
Create an event template with the following data:

Settings	Event template
New or copy	From scratch
Name	External quality check
Description	Package is chosen for an external quality check
Probability distribution	Discrete
Parameters	X: 28 Y: 2
Sub-events	None
Procedure	Name: Unpacking package Category: cost not accounted Time type: minutes Time costs: range from 5 to 30 Money cost: 0 Name: Packing package Category: cost not accounted Time type: minutes Time costs: range from 5 to 10 Money cost: 5

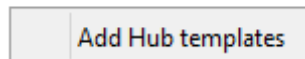
Since there are events available in the event catalog, it is possible to add events to all parts of the supply chain. Now it's time to add hubs. Similar to events, the hubs should be added to the hub



templates catalog. This can be done by clicking on *Master Data*, then *Hub templates* *Hub template catalog* or use the hotkey: CTRL+H.



The hub template catalog should appear. By right-click in the opened screen, this window pops up.



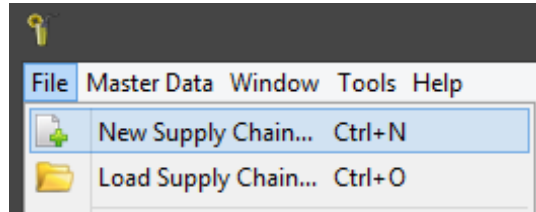
When clicking on the *Add hub templates*-option or by using the hotkey, CTRL+SHIFT+H, somewhere in the application, the wizard for creating hubs will show up. Follow this wizard and fill in the information that you want. More information can be found in section 5.2: Hub. Create two hubs. One as a starting point and one as an end point with the following data:

Attribute	New York	Amsterdam
New or copy	From scratch	Copy from -> Hub1
Name	New York	Hub2
Description	This is the start of the supply chain	This is the end of the supply chain
Icon	Use default (so do not change)	Use default (so do not change)
Location	Continent: North America Country: United States Street: 8 th Ave House number: 625 City: New York Zip code: 10018 State/Province: NY	Continent: Europe Country: Netherlands Street: De Ruijterkade House number: 7 City: Amsterdam Zip code: 1013 AA State/Province: Noord-Holland
Procedures	Name: Loading truck Category: cost not accounted Time type: minutes Time costs: range from 10 to 50 Money cost: 30	Name: Unloading truck Category: cost not accounted Time type: minutes Time costs: range from 30 to 50 Money cost: range from 20 to 30 Name: Storing in warehouse Category: cost not accounted Time type: minutes Time costs: 30 Money cost: 20

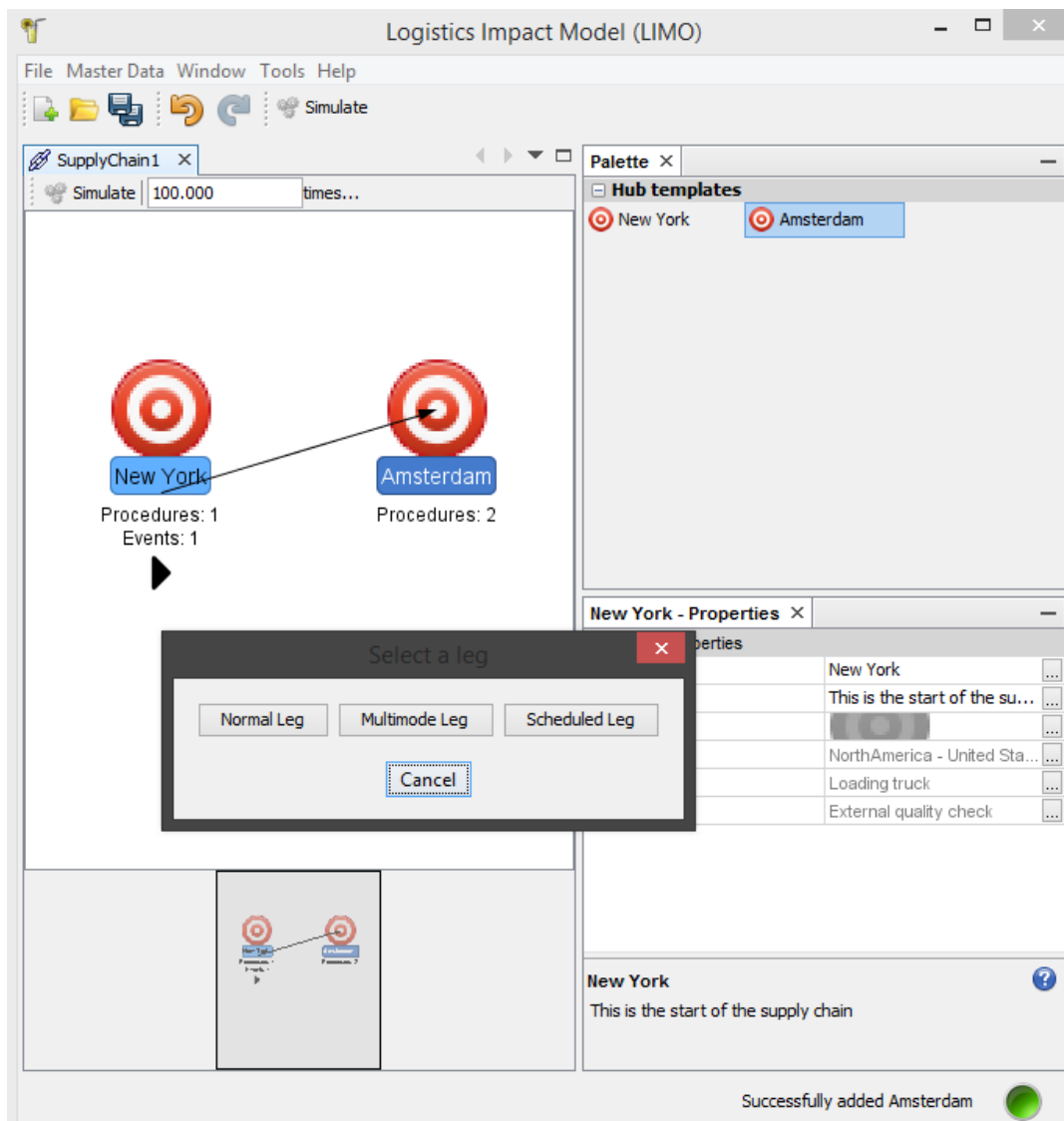
Events	Add the <i>External quality check</i> -event	
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4.2. Create a supply chain

Now you can start to make your first supply chain. Use the hotkey: CTRL+N or in the menu bar *File*, *New supply chain*.



Fill in a name for the supply chain in the window, which pops up. From here on it gets interesting ... and more easy. From the *Palette* in the right upper window drag two hubs into the supply chain editor screen. In case the *Palette* is closed, click on the “+”-sign and the hubs you just made, will appear.



Now hold CTRL and click and hold with the left mouse button on the first hub and drag to the second hub, where both buttons can be released. Now the leg wizard pop up and you can make your first leg with the following information (for more information see 5.3: Leg):

Attributes	Event
Leg type	Normal leg
New or copy	From scratch
Name	Transport by airplane
Description	Transportation by KLM Airlines from New York to Amsterdam
Icon	Use default (so do not change)
Procedures	Name: Transportation Category: cost not accounted Time type: hours Time costs: range from 6 to 12 Money cost: 100
Events	None

4.3. Simulate a supply chain

Now your first supply chain is ready for simulation. This can be done by clicking the *Simulate*-button on top of the window or in the toolbar above.

If you did everything right, the totals should look similar to the table below. Some minor differences are possible, because of random simulation values.

Totals	By Category	By Node				
Name	Costs Min	Costs Avg	Costs Max	Lead Times Min	Lead Times Avg	Lead Times Max
Total	170.0	175.02	180.0	430.81	640.68	848.21
	Extra Costs Min	Extra Costs Avg	Extra Costs Max	Delays Min	Delays Avg	Delays Max
	0.0	0.93	5.0	0.0	5.88	39.96

Congratulations! You just created your first supply chain using LIMO. The next sections describe in detail all the functionality of LIMO.

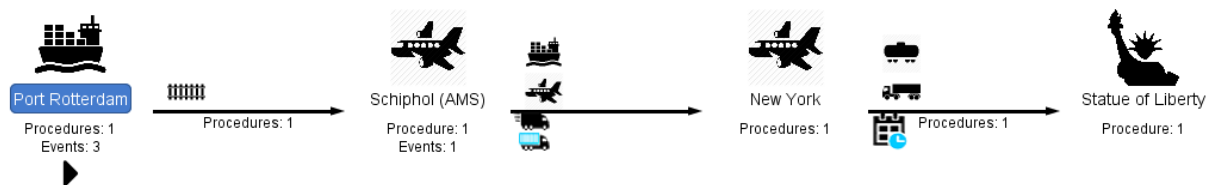
5. LIMO concepts

Logistics Impact Model (LIMO) requires some basic logistical knowledge and some explanation about how these logistical concepts are implemented in LIMO. The following sections explain different terms which are used in LIMO. This should give sufficient background knowledge for using LIMO. Each section starts with a definition of the term and afterwards shows how this concept is implemented in LIMO.

5.1. Supply Chain

A supply chain is a defined route between several location, including various types of logistical handlings (e.g. unloading, loading or custom controls).

The image below shows a supply chain. This supply chain contains four locations (hubs). The supply chain starts in *Port Rotterdam*, then there is a route to *Schiphol in Amsterdam (leg)*, from *Schiphol* there is a leg to *New York* and finally there is a leg to the *Statue of Liberty*. The starting point of the supply chain is marked by the black arrow below *Port Rotterdam*. The start- and end-point of a supply chain is always a hub. A supply chain always has a starting point and each hub in the supply chain should be part of the route.



All the sub parts of the supply chain (legs, hubs, events, procedures) are explained in the following sections.

5.2. Hub

A hub is defined as a location in LIMOs. Hubs can contain logistical handlings such as unloading cargo, loading cargo or custom controls. The logistical handlings are defined as *procedures* and *events* in LIMO.

Every hub should have at least one procedure. If no logistical handlings take place in a location which can have effect on the costs and time delay (e.g. a parking lot, where a truck stops for a while), the location does not add value in LIMO. It is possible to add multiple procedures and events to a hub.

Hubs are connected by legs. It is not possible within LIMO to add hubs, but leave them unconnected. Each hub should be part of the route from the start point to the end point. One hub should be set as the starting point of a supply chain, the end point is automatically identified by LIMO.



The image above shows a graphical representation of a hub. A hub always has a name which is used to identify the hub, an image and a set of procedures and events. This hub also has a *start hub arrow*, this arrow indicates that this hub is the start point of the supply chain. A supply chain can only contain one start point.

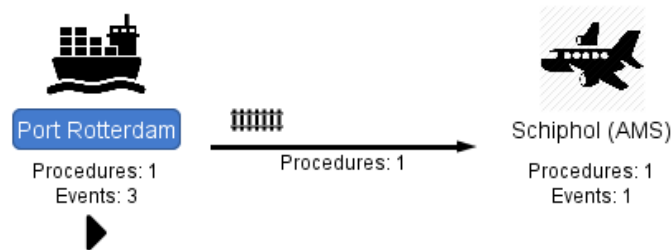
5.3. Leg

A route between two hubs is defined as a *Leg* in LIMO. Legs always have an origin (start point) and a destination (end point). The origin and destination of a leg are always hubs. It is not possible to create a Leg with a start point, intermediate point and an end point. It is only possible to create a Leg between **two hubs**.

There are three kinds of legs: *normal legs*, *multimode legs* and *scheduled legs*. The following sub-sections describe the three different legs.

5.3.1. Normal leg

Normal legs are the simplest kind of legs. A normal leg is a route between two points. This route contains logistical handlings which always occur (e.g. transportation via truck) named procedures, and optionally logistical handlings which occur with a certain probability (e.g. custom controls, truck breaks down, traffic jam) named events. Events and procedures are explained in more detail in section 5.4 and section 0.



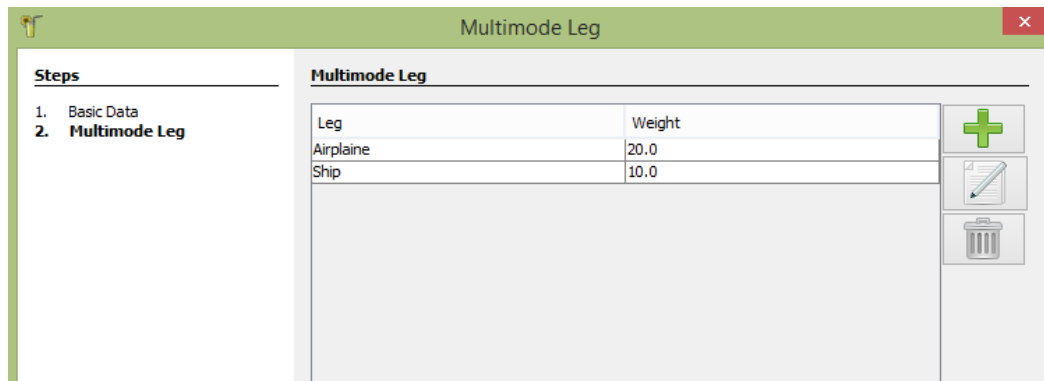
Just like all other kinds of legs, the normal leg has a name, description and icon. However, the name and description are not displayed in the graphical supply chain overview.

5.3.2. Multimode leg

A multimode leg is a collection of normal legs. A multimode leg contains multiple normal legs, each with a probability. Multimode legs are used in situations when goods are sometimes transferred by ship and sometimes transferred by truck. With the probability factor (also called weight), it is calculated which leg should be executed. The multimode leg can be identified by the *double truck icon* which is displayed below the multimode leg.



For example, in the example supply chain, the goods are sometimes transferred by ship and sometimes by boat. The *ship leg* has a weight factor of 10 and the *airplane leg* has a weight factor of 20 (see figure below). This will mean that one-thirds ($10/(10+20)$) of the time, the *ship leg* is executed and two-thirds ($20/(10+20)$) of the time the *airplane leg* is executed.



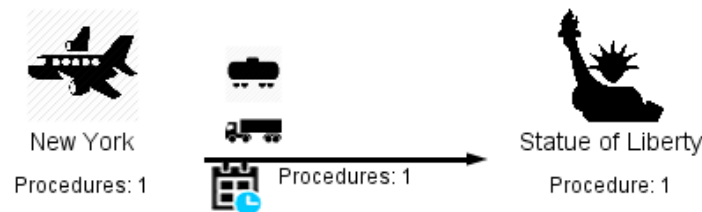
Leg	Weight
Airplane	20.0
Ship	10.0

The weight factor can be seen in the figure above. The weight factor can be all real numbers with a positive value. The probability factor is calculated by dividing the weight by the sum of the weights. Therefore, if the weights of the previous example were changed to 2 (instead of 20 for the airplane) and 1 (instead of 10 for the ship), the probability factor is still the same.

$$probability\ factor = \frac{weight}{\sum weight} \text{ where } weight \in \mathbb{R} \text{ and } weight > 0$$

5.3.3. Scheduled leg

A *scheduled leg* is a leg which has a 'schedule' and an alternative leg. This alternative leg is executed when the scheduled part of the leg cannot be caught. The scheduled leg can be identified by the *calendar icon* which is displayed below the scheduled leg.



A scheduled leg is more complex than the other legs. The scheduled leg requires the following attributes. Within these attributes time is always counted in minutes:

Attribute	Description
Expected time	The expected time from the start of the scheduled leg when the consignment arrives. The delay of the previous hub is added to the expected time.
Waiting time limit	Maximum time that a consignment will wait, between time of arrival of the consignment and the departure times (acceptance times).
Acceptance times	The departure time relative to the expected arrival time. To make it more specific: The amount of minutes counted from the expected time to the time of departure of the scheduled parts
Alternative leg	The alternative route which is executed when the waiting time limit is exceeded

For example: The expected time is the time to go from a hub to the scheduled part of the leg (e.g. ferry). Possible delay from the hub before is added to the expected time. Possible delay before this hub is not taken into account. In this case a truck has a drive which takes 45 minutes to the ferry from the warehouse, where was a 15 minutes delay, because loading took longer than expected. This makes in total an expected time of 60 minutes.

The waiting time limit is defined by the logistical department. In this example, a truck will not wait for more than one hour for a ferry. In that case the truck will drive further over the bridge, which takes a lot longer.

The acceptance times is the amount of minutes until the ferry departures, counted from the moment the truck is expected to arrive at the ferry. Counted from the beginning of the leg, a ferry will leave at minute 65, 80, 95 and 215. The acceptance times should be entered. This is the departure times minus the expected times. In this case should be entered: 5 (65-60), 20 (80-60), 35 (95-60), 155 (215-60). Expected time, waiting time and acceptance times are all whole positive numbers.

$$\text{arrival time} = \text{expected time} + \text{delay of hub}$$

$$\text{departure time} = \text{arrival time} + \text{expected time}$$

If the truck has delay (for example because of events, which occurred) and arrives at the ferry at minute 100 (from the beginning of the leg), it was not able to catch the ferry. The next ferry goes 115 minutes after that moment. The maximum waiting time is set at 50 minutes. This means the alternative leg will be taken and is therefore executed. In more abstract terms, the alternative route is not used when the following statement is true for a departure time:

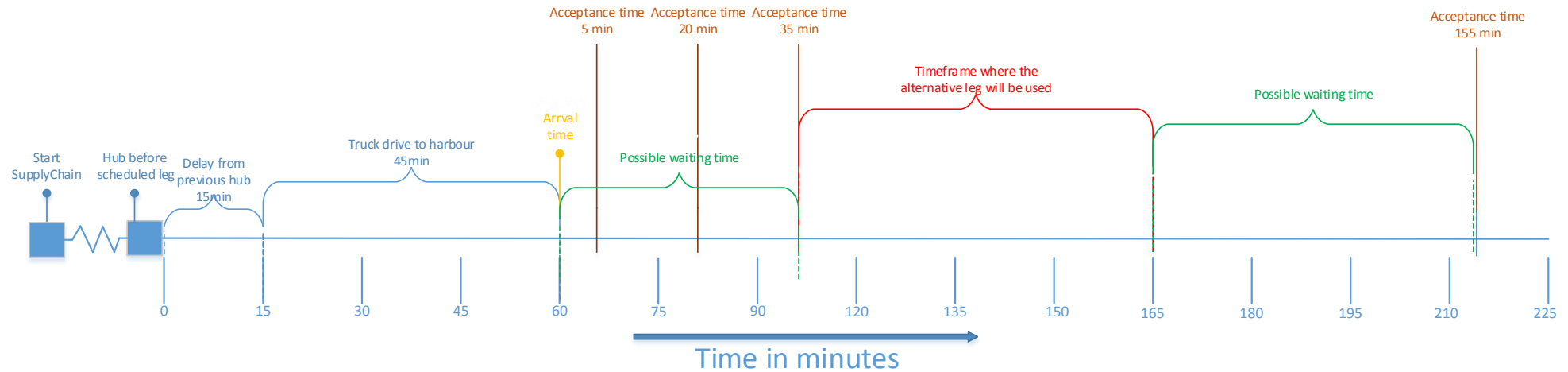
$$(\text{arrival time} + \text{waiting time}) > \text{departure time}$$

and $\text{arrival time} \leq \text{departure time}$

The table below shows a summary of the theory. The next page shows a graphical representation of this example to clarify the concept of a scheduled leg.

Terminology	Time from start of leg	Values which should be entered
Expected time	60	60
Waiting time	50	50
Acceptance times	65	5
	80	20
	95	35
	215	155

Important to mention is that both legs, scheduled and alternative, have the full properties of a normal leg, so both can have procedures and events.



As can be seen in the figure above, the delay before the Hub is not relevant to the scheduled leg. The figure is a graphical representation of the example which was describe before. The expected time is 45 minutes and the delay of the consignment was 15 minutes. This results in an arrival time of 60 minutes. The acceptance time is 5, 20, 35 and 155 minutes. When taking into account the arrival time, this results in departure times of 65, 80, 95, 215 minutes. The maximum waiting time is 50 minutes.

The figure above shows that the consignment will be shipped using the alternative route if the consignment arrives after 95 and before 165 minutes because the waiting times states that a consignment will wait for maximum 50 minutes. When a consignment arrives after 215 minutes, it is also shipped using the alternative route. In the figure above, the consignment has a delay of 15 minutes, therefore the consignment will wait until the first departure time (65 minutes).

5.4. Procedures

A procedure is a logistical handling which is always executed and influences the costs and/or time of the supply chain. Procedures require the following attributes:

Attribute	Description
Category	Procedures can have categories. These categories are used when simulating a supply chain. All costs and time delays of all procedures in a category are summarized. The category is used to make it possible to assign costs and time delay to a category (e.g. transportation, administrative handlings, warehouse handling)
Time cost	The time delay which is caused by this procedure. This can either be a static value or a range of values. When a range of values is chosen, a random value between the range is selected when simulating the supply chain.
Time type	The time delay value type and can only be <i>minutes</i> , <i>hours</i> , <i>days</i> and <i>weeks</i> . A time cost value of 180 with the <i>minutes</i> -time type is the same as a time cost value of 3 with the <i>hours</i> -time type.
Money cost	The costs which are caused by this procedure. Just like the time cost, the money cost can either be a static value or a range of values. When a range of values is chosen, a random value between the range is selected when simulating the supply chain. The costs are defined in an abstract unit instead of euros or dollars.

Hubs and legs have a list of procedures. It is required to have at least one procedure due to the definition of a hub and leg. The figure below shows a list of procedures. The '<->' sign indicates that a range is selected.

Procedures				
Procedure	Category	Time Cost	Time Type	Money Cost
Loading	Warehouse	1.0 <-> 3.0	Hours	10.0 <-> 120.0
Transportation	Transport	45.0 <-> 90.0	Minutes	60.0
Unloading	Warehouse	30.0 <-> 60.0	Minutes	60.0

In the figure above, there are three procedures: loading, transportation and unloading. The loading procedure takes 1 to 3 hours and costs 10 to 120 units. The transportation procedure takes 45 to 90 minutes and always cost 60 units. Finally, the unloading procedure takes 30 to 60 minutes and costs 60 units. Each time a supply chain is simulated, the ranges are calculated again.

5.5. Events

An event is a logistical handling which is not always executed and can have influences on the costs and time of the supply chain. When an event is not executed, it cannot have influence on the costs and time of a supply chain. Whether an event is executed or not, is calculated via statistical distributions. These statistical distributions are implemented in a comparable way of how Microsoft Excel implemented the distributions. Therefore, some statistical knowledge is required in order to use events properly. The following distributions are supported:

- Cauchy
- Chi Squared
- Discrete
- Exponential
- F
- Gamma
- Log Normal
- Normal
- Poisson
- Triangular
- Weibull

An event requires the following attributes:

Attribute	Description
Probability distribution	The probability distribution which is used to calculate whether an event is executed or not.
Probability distribution parameters	The parameters (attributes) are required to calculate whether an event is executed or not. The parameters change depending on which probability distribution is chosen. For example: the normal distribution requires a <i>mean</i> , <i>lower bound</i> , <i>upper bound</i> and <i>standard deviation</i> while the discrete deviation only requires a X and Y value.
Procedure list	An event can contain multiple procedures. If an event is executed, these procedures are executed. The procedures can have an influence on the time delay and money costs of a supply chain.
Sub-events	Sub-events are events which belong to an event. The sub events are executed if an event is executed (or not) depending on the execution state.

In the figure below illustrates an example of an event. The event which can be seen in this figure is named *Physical inspection* and is executed 1 out of 5 times. This is configured using a discrete probability distribution with the values 1 and 5.

Basic Data

Name
Physical inspection

Description
Based on scan results, in 1 of the 5 cases customs may open a container.

Probability distribution
Discrete

This distribution calculates the probability of X / Y.
X is elemnt of (negativ infinity, positiv infinity)
Y is elemnt of (0, positiv infinity)

Parameters

Y	5
X	1

5.5.1. Sub-events

As can be seen in the figure below, the *Physical inspection*-event has two sub-events: *Document inspection* and *Detailed shipping information requested*. These sub-events are part of the *Physical inspection*-event and depending on the execution state of this event, the sub events are executed.

Sub Events	
Event	Document inspection
Event	Dependency
Document inspection	EXECUTED
Detailed shipping information requested	NOT_EXECUTED

The table below describes the three different dependency states. In the description, the main event is called the parent-event and the sub events are described as child-events. The execution state of an event describes if an event is executed or not.

Dependency	Description
Executed	Sub-events (child-events) with this dependency can only be executed if their parent-event is executed.
Not executed	Sub-events (child-events) with this dependency can only be executed if their parent-event is not executed.
Independent	Sub-events (child-events) can always be executed. The execution state of their parent-event does not influence this. The independent state is a way to group events together. A sub-event with the independent state can be viewed as a separate event.

The *Document inspection*-sub event has an *executed*-dependency. This means that if the parent-event (in this case *Physical inspection*) is executed (this happens 1 out of 5 times), the *Document inspection*-sub event is ran. If the *Physical inspection*-event is not executed (this happens 4 out of 5 times), the *Document inspection*-sub event can never be ran due its dependency state.

The *detailed shipping information requested*-sub event is, in contradiction to the *document inspection*-sub event only ran when the *Physical inspection*- event is not executed. This means that whenever the *Physical inspection*-event is not executed, the customs may request some additional shipping information. However, if the customs decide to do a *Physical inspection*, they do not require additional shipping information.

A more abstract example would be: Let P equal a parent-event, let E equal a child-event with the dependency *executed*, let N equal a child-event with the dependency *not executed* and let I equal a child event with the dependency *independent*.

$$P \rightarrow E$$

$$\neg P \rightarrow N$$

$$P \nrightarrow I$$

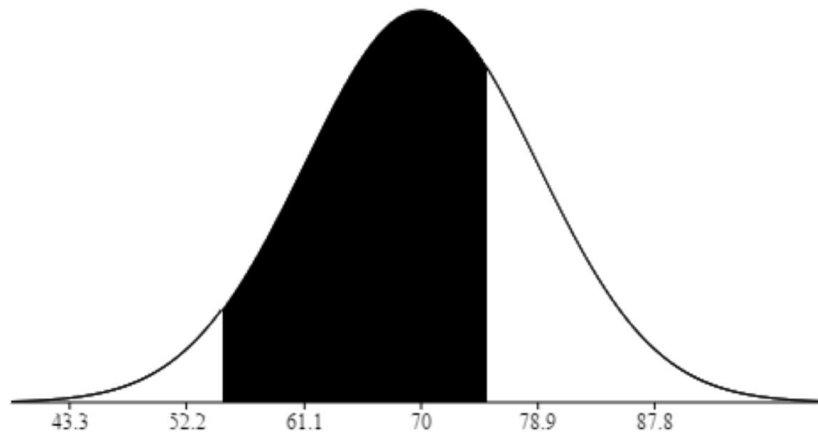
Note: In this example, P implies E. This does not mean that when event P is executed, event E is executed. When event P is executed, the statistical distribution of E is calculated and this statistical distribution defines whether E will be executed. However, if P is not executed, E will never be executed.

5.5.2. Probability distribution

The beginning of the Event section briefly discussed the probability distribution of events. In this section, the probability distribution is discussed in detail.

Basic Data											
Name	Detailed shipping information requested										
Description	When a container is not physically checked, detailed shipping information is sometimes requested										
Probability distribution	Normal										
<p>The normal (or Gaussian) distribution is a function that tells the probability that any real observation will fall between any two real limits or real numbers, as the curve approaches zero on either side. Mean is a real value variance > 0</p>											
<table border="1"> <thead> <tr> <th colspan="2">Parameters</th> </tr> </thead> <tbody> <tr> <td>Lower Bound</td> <td>55.0</td> </tr> <tr> <td>Standard Deviation</td> <td>8.9</td> </tr> <tr> <td>Upper Bound</td> <td>75.0</td> </tr> <tr> <td>Mean</td> <td>70.0</td> </tr> </tbody> </table>		Parameters		Lower Bound	55.0	Standard Deviation	8.9	Upper Bound	75.0	Mean	70.0
Parameters											
Lower Bound	55.0										
Standard Deviation	8.9										
Upper Bound	75.0										
Mean	70.0										

The figure above shows the details of the *Detailed shipping information requested*-sub event. This sub event uses *normal probability distribution* to check whether the sub event is executed or not. The figure below is a graphical representation of a *normal probability distribution* with a lower bound of 55, upper bound of 75, mean of 70 and a standard deviation of 8.9. The dark area is the *acceptance area*, when the calculated value is in this area, the event is executed.



Just like Microsoft Excel, LIMO calculates the cumulative value of the upper bound and subtracts the cumulative value of the lower bound. The following example shows how the *normal probability distribution* can be calculated in Microsoft Excel.

Let *UB (Upper bound)* equal `NORM.DIST(75;70;8,9;1)`

Let *LB (Lower bound)* equal `NORM.DIST(55;70;8,9;1)`

$$Probability = 100 * (UB - LB) = 66.69 \text{ percent}$$

This will mean that the *Detailed shipping information requested*-event is executed 66.69 percent of the time. The chance that the event is executed can be increased or lowered by changing the values of the *normal probability distribution*. If the upper- and lower bound are closer to the mean, the event will be executed less often.



The LIMO simulation will generate a number by taking into account the mean and standard deviation. The LIMO simulation will then check if the value lies between the lower- and upper-bound. If the value lies between those bounds, the event is executed. Therefore can be said that LIMO does not *calculates* costs and time delay but *simulates* them by rapidity (up to millions of times) generating numbers and check whether the numbers meet the requirements of the probability *distribution type*. This can be compared to the following Excel formula:

=NORM.INV(RAND();70;8,9)

This Excel formula shows a random number which is inserted in the inverse normal distribution formula. This number is then compared to the boundaries of the *normal probability distribution*.

5.5.3. Procedures

It was mentioned before in the attribute description table that an event has procedures. If an event is executed, the procedures which are set in the event are executed. These procedures then influence on the time and money of the supply chain. The figure below shows the procedures of the *Physical inspection*-event. This event has three procedures: *opening container*, *searching container* and *re-packing container*. All these procedures do not have influence on the costs of the supply chain but do cause a delay.

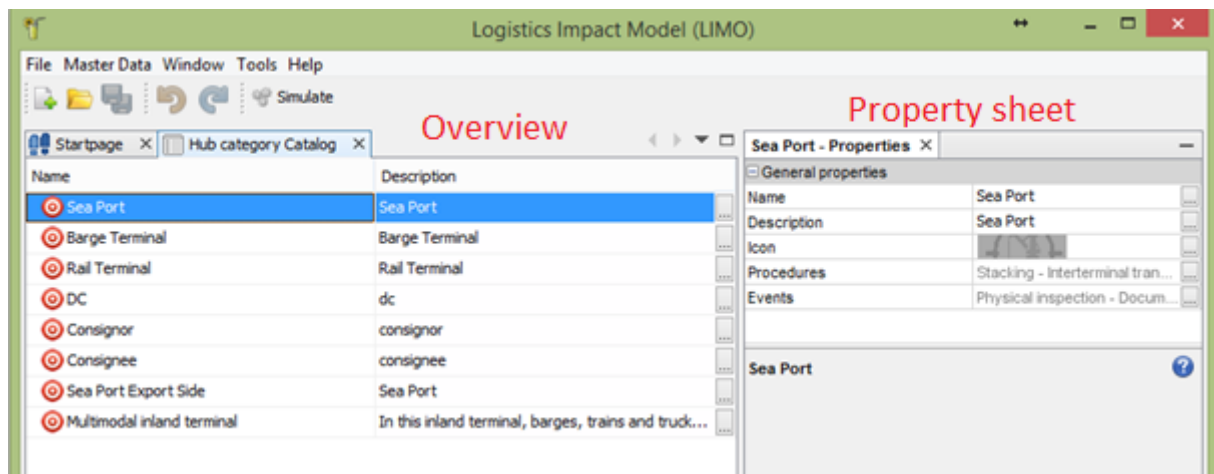
Procedures					
Procedure	Category	Time Cost	Time Type	Money Cost	
Opening container	Douane-zaken	5.0	Minutes	0.0	 
Searching container	Douane-zaken	0.0 <-> 16.0	Minutes	0.0	
Re-Packing container	Douane-zaken	0.0 <-> 8.0	Minutes	0.0	

Due the definition of procedures, all three procedures are executed. The *opening container*-procedure will cost a 5 minute time delay but does not make extra costs. The *searching container*-procedure creates a delay of 0 to 16 minutes and the *re-packing container*-procedure creates a delay of 0 to 8 minutes.

6. Master data

In the previous section, all concepts of LIMO were explained. In this section, some additional functionality named *master data* is explained. Master data is used to make it easier for users to re-use data. For example, it would not be nice that each time you want to create a hub called Venlo, you have to create this hub from scratch. It would be nice to have some hub templates so you can re-use the hub. This is possible with master data.

Master data is stored in the application; you can use the master data across multiple supply chains. The master data will always be there, no matter which supply chain you opened. The master data is stored in *catalogs* and they can be found in under the *Master data*-menu option. Each object has his own catalog. In the following sub-sections, the master data of all objects are discussed.



The image above shows the hub category catalog. The catalog is divided into two parts: overview and property sheet. The overview window is displayed at the left side and the property sheet is displayed at the right side. The overview window shows, as the name implies, a list of all items in the catalog (in this case: hub categories). If one item of this list is selected, the property sheet shows more information about this item. The property sheet shows all attributes of the selected item and provides a way to edit these attributes.

Another way of editing items is by right clicking on the item and choosing *edit*. A wizard will popup which can be used to edit the item. This wizard is exactly the same as the add-wizards. The wizards are an alternative of the property sheet but contain the same functionality as the property sheet.

6.1. Hub categories

Hub categories are partially filled hub objects which can be used to create hubs or hub categories. Hub categories contain the following attributes compared to all hub attributes:

Hub attributes	Hub categories
Name	Present
Description	Present
Icon	Present
Procedures	Present
Events	Present
Location	Not present, each hub should have a different location.

Hub categories can be used to fill a certain group of hubs with some default data. For example: a *harbor hub* should always have *unloading* and *loading* procedure independent on the location of the hub. An *airport hub* should always have a *customs physical inspection*-event independent of the location of the hub.

Hub categories can be added using the *Master data* menu option -> *Hub category* -> *New hub category*.

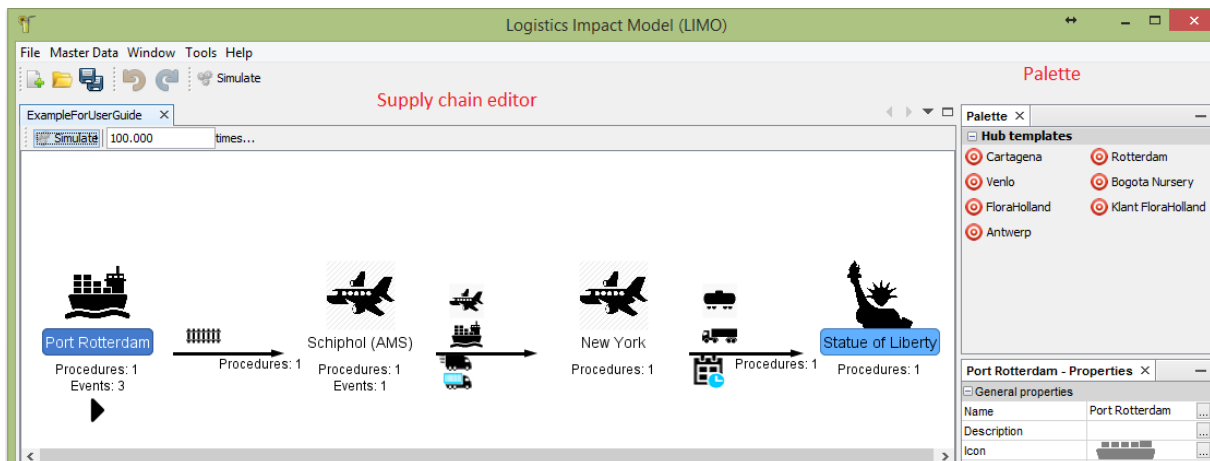
6.2. Hub template

Hub templates are ‘pre-filled’ hub objects which can be used across multiple supply chains. In contradiction to the hub categories, hub templates do contain a location attributes. Hub templates can be created by copying an existing hub template or by using a hub category.

Hub attributes	Hub template
Name	Present
Description	Present
Icon	Present
Procedures	Present
Events	Present
Location	Present

The main difference between hub categories and hub templates is that hub templates do represent a certain location and that hub categories represent a kind of hubs (categories of hubs). The hub templates can be used for creating supply chains.

Hub templates can be added using the *Master data* menu option -> *Hub templates* -> *New hub template*. Hub templates can be edited the same way as hub categories (by right click -> *edit* or via the property sheet).



The image above shows an example of how LIMO would look like when editing a supply chain. More about supply chains can be found in section 6. The right windows shows a palette. This palette contains all hub templates. These hub templates are used to create supply chains.

6.3. Leg template

The leg templates are 'pre-filled' normal leg objects which can be used across multiple supply chains. The leg templates have the following attributes:

Leg attributes	Leg template
Name	Present
Description	Present
Icon	Present
Procedures	Present
Events	Present

The leg templates can be used if certain legs always contain some procedures/events or should have the same icon. An example of a leg template would be that all *truck*-legs should have an *load truck*-procedure, *drive truck*-procedure and a *truck breakdown*-event, they also should have an icon of a truck. If a leg template with these procedures and events is created, new legs can be based on this leg template. It is not required to add these default procedures each time a new leg is created.

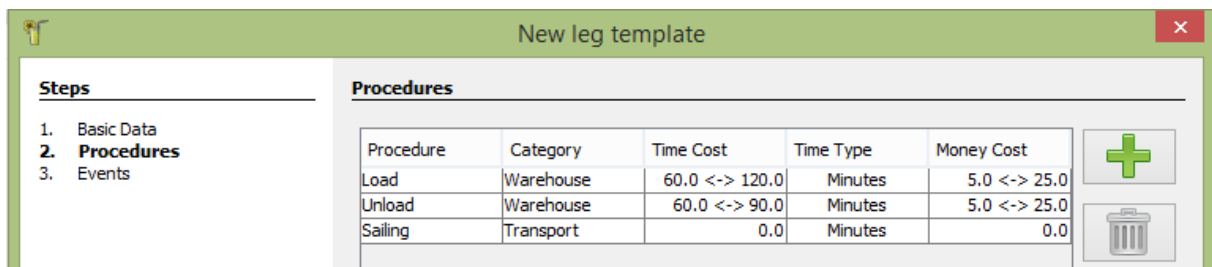
Leg templates can be edited and added in the leg catalog which can be found at the *Master data* menu option -> *Leg templates* -> *Leg template catalog*.

6.4. Procedure categories

Procedure categories are used to account costs and time delay to a certain category. Therefore the use of procedure categories are significantly different than hub categories.

Totals	By Category	By Node			
Name	Costs Min	Costs Avg	Costs Max	Lead Tim...	Lead Tim...
Douane-z...	0.0	0.0	0.0	0.0	0.0
IT	0.0	0.0	0.0	240.0	240.0
Transport	31.2	105.32	179.01	426.27	599.58
costs not ...	0.0	0.0	0.0	0.0	0.0

Procedure categories are only used for grouping certain costs and time delays. The figure above displays simulation results of a supply chain. The *Total* tab shows the total costs and time delays of the supply chain simulation. The *Category* tab shows all costs and time delay grouped by category. This is where the procedure categories are used. It is used to drill down the total costs in categories so it is easier to see where the costs and time delay arose.



Procedure	Category	Time Cost	Time Type	Money Cost
Load	Warehouse	60.0 <-> 120.0	Minutes	5.0 <-> 25.0
Unload	Warehouse	60.0 <-> 90.0	Minutes	5.0 <-> 25.0
Sailing	Transport	0.0	Minutes	0.0

When creating a procedure, it is possible to assign the procedure to a procedure category as can be seen in the figure above. When no category is selected, *costs not accounted* is selected as procedure category.

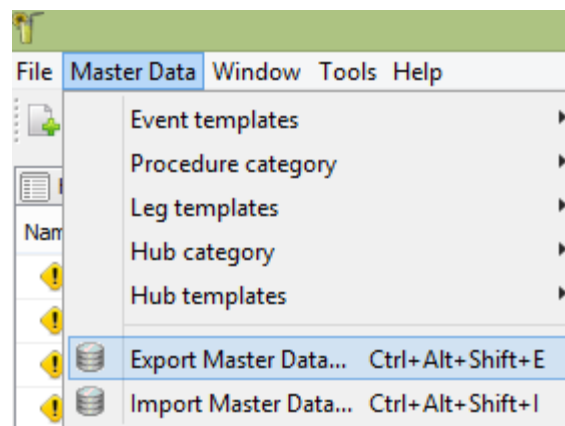
6.5. Event template

Event templates are ‘fully filled’ event objects. The event templates should be created before creating a supply chain. Event templates contain all kind of statistical information, sub-events and procedures as explained in section 0.

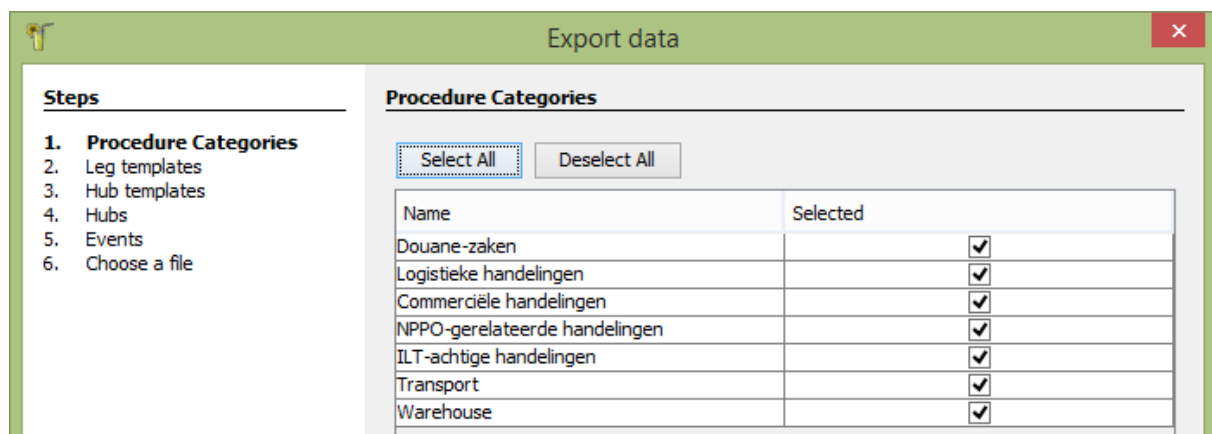
It is recommended to first create the sub-events and afterwards create the ‘parent-event’ and add the sub-events to this event. Working this way ensures that there are not too much wizards open at the same time.

6.6. Export master data

After working with the LIMO application for some while, LIMO will be filled with a set of master data. Creating this master data is time consuming work and therefore it would be nice to not create the master data completely from scratch when using another computer. This is where the import and export master data functionality is useful.



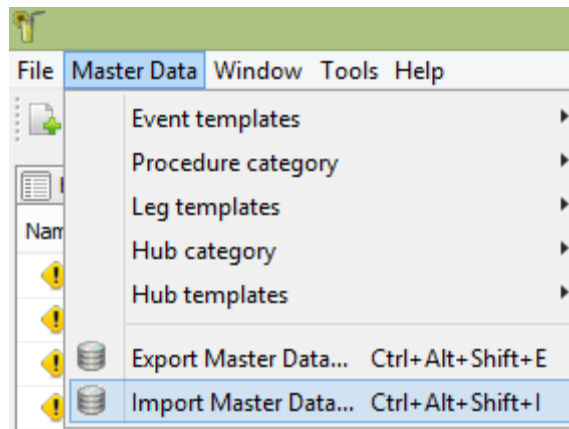
For exporting master data to a file click on the *Master data* menu option -> *Export master data*. A wizard will pop up. The first step is to select all object which should be exported, this is displayed in the figure below.



The last step of the wizard is to select a location and file name for the exported master data. This is the location where the master data is saved. When the wizard is completed, a *.lef*-file is created in the location which was selected. This file can be copied, e-mailed, moved to another computer. This computer can then import the master data. It is recommended to export the data once in a while for backup purposes. When a computer breaks down and no backup of the master data is created, all master data needs to be made from scratch.

6.7. Import master data

Importing master data is similar to exporting master data. For importing master data, a *.lef*-file is required. This file can be generated by exporting master data (see previous section).



For importing master data from a file, click on the *Master data* menu option -> *Import master data*. A wizard will pop up. The first step is to select the *.lef*-file which should be imported.

Resolve conflicts

Number of all Entities: 32
Already imported entities: 0
Number of Conflicts: 2
Number of entities that have an older version than yours: 30

Select All Deselect All

Old Entity	Date of Old Entity	New Entity	Date of New Entity	Overwrite your entity?
Physical inspe...	4-jun-2015	Physical inspection	2-mrt-2015	<input checked="" type="checkbox"/>
Sea transport	8-jun-2015	Sea transport	28-jan-2015	<input type="checkbox"/>

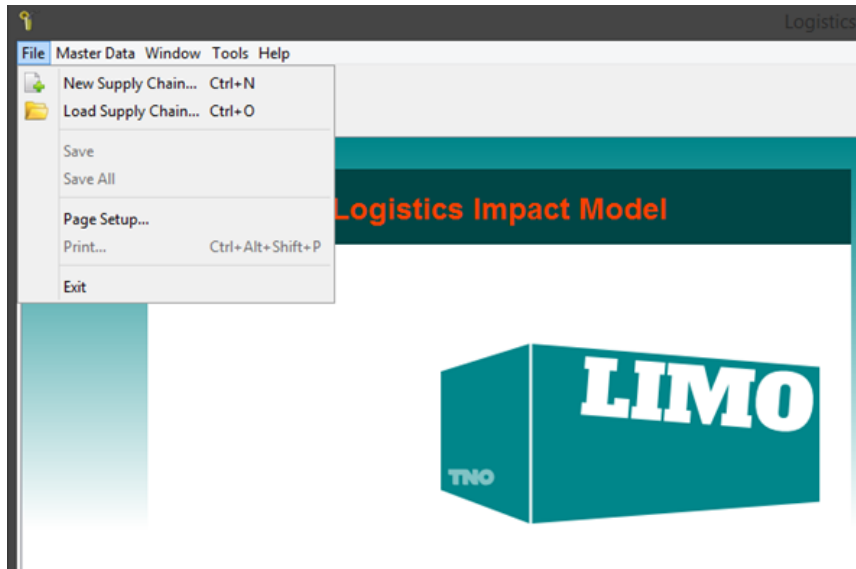
The next step is not required when not master data is present in LIMO or no conflicts occur. Conflicts can be caused if the same set of master data is imported multiple times. The master data is then already present in LIMO. When conflicts occur, the LIMO wizard will provide the option to overwrite or skip parts of the backup. When overwriting data in LIMO, all changes are lost and restored to the state of the backup. When the overwrite option is not checked, the data will be skipped and will not be changed.

7. Supply chain

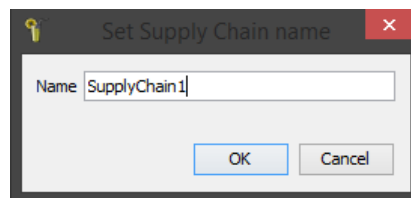
In the previous section the concept of *master data* was explained. This master data is required to be able to create a new supply chain.

7.1. New supply chain

To create a new supply chain, click *File* in the menu bar and then *New supply chain*.



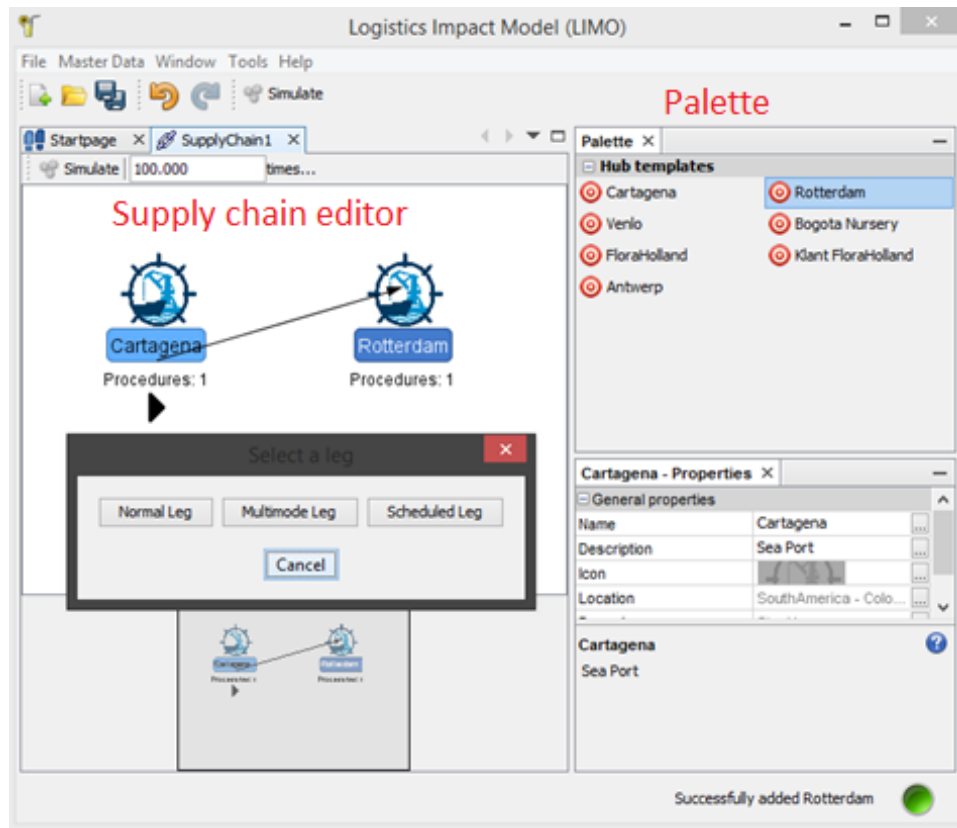
Afterwards a wizard pops up, where a name for the supply chain can be entered. This name is only used to identify the supply chain.



After pressing *OK*, an empty supply chain editor screen appears, where a supply chain can be build. Before being able to drag and drop hubs from the palette into the supply chain editor, hubs should be added to the hub template catalog. This can be done at *Master data/Hub templates/Hub template catalog* as can be read in section 6.2. Another possibility is to import master data from a previously stored master data file. This can be read in section 6.7.

From the palette, hub templates can be dragged and dropped into the supply chain. When a hub is added to a supply chain, this is a hub on itself and is based on the values of the hub template. The hub is not linked to the hub template. This means that when a hub is edited (e.g. name changed or event/procedure added) only this hub is changed: NOT the hub template in the palette. If changes should be made to the templates, the catalog should be opened and the templates can be changed.

This can be compared to Microsoft PowerPoint. It is possible to use a fancy PowerPoint template. You can then add information which is specific to your presentation. However, the template does not change when you change your presentation. The template stays the same, so the next time you can re-use the template for another presentation. This is exactly how the hub templates and hubs work in LIMO.



After two hubs are added to the supply chain window, a leg can be added. This is done by pressing and holding the control-button and left-mouse button and move the mouse from the first to the next hub. When a line is drawn, release the control and left mouse-button. A window will popup which displays the three different leg types. Based on the leg type which is chosen, a wizard will popup which can be used to create the leg.

It is possible to edit legs and hubs, but also the events and procedures within, after they are added to a supply chain. This can be done by using the property sheet window or by right clicking on a hub/leg and selecting *Edit*.

It is also possible to delete hubs and legs. Deleting can be done by right clicking on a leg/hub and selecting *Delete*. This action can also be undone by using the *undo*-button in the toolbar or by pressing CTRL and Z at the same time.

7.2. Save/Load supply chain

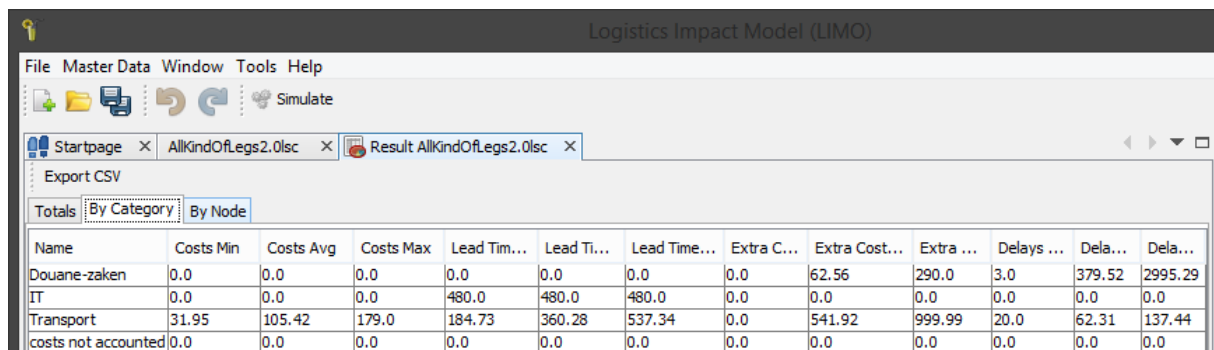
It is possible to save and load a supply chain. A supply chain is saved as a *.lsc*-file (LIMO supply chain file). This ensures that it is possible to exchange supply chains between users and devices. Like the name implies, the supply chain is saved. The master data is not saved in the supply chain file. Exporting master data is described in section 6.6. It is recommended to regularly backup the supply chain files to prevent data loss.

8. Simulation results

The simulation is ran the amount of times, which is entered at the top left of the supply chain editor. The default value is hundred thousand times, but this can be changed if wanted. When the *simulate*-button is clicked, LIMO starts simulating the supply chain up to thousands of times. LIMO than uses the results of all the simulations and displays it in a table.

The result screen shows, as can be seen in the figure below, the costs and lead time and the extra costs and lead time of events specifically. Of each of these values a minimum, average and maximum value are shown.

- Costs/time: Costs caused by procedures
- Extra costs time: Costs caused by events



The screenshot shows the LIMO software interface with the 'Result AllKindOfLegs2.0lsc' tab selected. The table displays simulation results for various categories and nodes. The table has columns for Name, Costs Min, Costs Avg, Costs Max, Lead Time Min, Lead Time Avg, Lead Time Max, Extra Costs Min, Extra Costs Avg, Extra Costs Max, Delays Min, Delays Avg, and Delays Max. The rows include 'Douane-zaken', 'IT', 'Transport', and 'costs not accounted'.

Name	Costs Min	Costs Avg	Costs Max	Lead Time Min	Lead Time Avg	Lead Time Max	Extra Costs Min	Extra Costs Avg	Extra Costs Max	Delays Min	Delays Avg	Delays Max
Douane-zaken	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.56	290.0	3.0	379.52	2995.29
IT	0.0	0.0	0.0	480.0	480.0	480.0	0.0	0.0	0.0	0.0	0.0	0.0
Transport	31.95	105.42	179.0	184.73	360.28	537.34	0.0	541.92	999.99	20.0	62.31	137.44
costs not accounted	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

As can be seen in the figure above, the simulation results are displayed in three different tabs: total, by category and by node.

- The *total*-tab shows the summation of all costs and time delay for the whole supply chain. This tab is useful to quickly compare complete supply chains.
- The *by category*-tab shows the summation of all costs and time delay sorted by procedure category. This is explained in more detail in section 6.4. This tab is useful to see who caused costs and time delays.
- The *by node*-tab shows the summation of all costs and time delay per node. A node can be a leg or hub. This tab is useful to see where costs and time delays occur in the supply chain.

The simulation results can be exported to CSV by clicking in the left top corner of the result screen *Export CSV*. The exported CSV file can for example used in Microsoft Excel. Excel can be used to quickly generate diagrams of the simulation results.

9. Hotkeys

To make LIMO more user friendly, hotkeys were introduced. Hotkeys are key combinations which can be used to quickly execute small actions. The following table shows an overview of the most important hotkeys. The hotkeys can be assigned to other keys by changing the settings. The settings can be found at the *Tools*-menu option -> Options -> Keymap tab. This setting page also contains a list of all hotkeys.

F1	Open Manual
F2	Open Cheat Sheet
CTRL + 1	Open Properties
CTRL + 2	Open Palette
CTRL + P	Open Procedure Category Catalog
CTRL + E	Open Event Category Catalog
CTRL + H	Open Hub Category Catalog
CTRL + N	Create a New Supply Chain
CTRL + S	Save supply chain
CTRL + O	Open a supply chain
CTRL + Z	Undo action
CTRL + Y	Redo action
CTRL + ALT + H	Open Hub Type Catalog
CTRL + ALT + L	Open Leg Type Catalog
CTRL + SHIFT + E	Open Event Wizard
CTRL + SHIFT + H	Open Hub Wizard
CTRL + ALT + SHIFT + H	Open Hub Type Wizard
CTRL + ALT + SHIFT + L	Open Leg Type Wizard
CTRL + ALT + SHIFT + P	Print
CTRL + ALT + SHIFT + E	Export Master Data
CTRL + ALT + SHIFT + I	Import Master Data

10. Help and contact

For remarks, questions, bug reports or feature requests, contact the Software Factory group of the Logistics Impact Model via the following e-mail address: limo@fontysvenlo.org

The official LIMO website contains more information about the project including a detailed planning of the project and the complete source code. The official LIMO website can be found at:

<http://limo.fontysvenlo.org>

LIMO is sponsored by Fontys Venlo Hogeschool Techniek en Logistiek on request and with help of TNO Sustainable Transport and Logistics.



10.1. About TNO

TNO is an independent applied research organization that employs more than 3,000 specialists. TNO connects people and knowledge to create innovations that boost the competitive strength of industry and the well-being of society in a sustainable way. TNO focusses on transitions or changes in five social themes: Industry, Healthy Living, Defence, Safety & Security, Urbanization and Energy.

TNO is a major player in a growing international network of leading scientific institutes, companies with ambitious development profiles, universities and other partners in knowledge. The knowledge TNO develops, integrates, will make applicable and puts into practice will only have value if TNO can use it to have a real social and economic impact.

Besides different establishments in Delft TNO has other ones in Apeldoorn, Bergen op Zoom, Den Haag, Den Helder, Eindhoven, Enschede, Groningen, Helmond, Hoofddorp, Leiden, Rijswijk, Soesterberg, Utrecht and Zeist, as well as outside the Netherlands in Brussel, Doha, Oranjestad, Toronto and Yokohama.

10.2. About Fontys Venlo

Fontys Venlo Techniek en Logistiek is one of the three institutes of the Fontys International Campus Venlo and contains Technical, Logistics and Informatics studies.

The Logistics Impact Model application is developed as part of the Software Factory project of the Software Engineering and Business Informatics course. This Software Factory project includes a 'real' customer (in this case: TNO).

The duration of the Software Factory project is one semester (five months). The LIMO tools is the result of two Software Factory semesters.